

The word 'ocean' denotes an infinite expanse. This meaning is borne out by the oceans' breadth — covering three-fourths of Earth, the oceans hold life that literally enables us to live. Marine ecosystems, from tiny microbes to huge whales, work in astonishing synchrony, creating over 50% of the Earth's oxygen. Ocean life, from corals to seagrasses, sequester one-third of the carbon emitted by human beings, folding this away as 'blue carbon' in the depths. Alongside, the oceans absorb the sun's heat, while their currents generate climatic conditions from warmth to breeze. Marine life, which nourishes three billion people, is a pillar of Earth's biogeochemical cycles. Humanity simply cannot survive without the oceans of life.

Yet, humans seem determined to destroy these opalescent seas — pollution, by agricultural chemicals to industrial effluents, sewage and plastic, is choking these. While oil spills cover miles in dark catastrophe, mangroves are relentlessly destroyed for parking lots and palm oil. Perhaps the greatest evidence of humanity's greed is the extent of fishing in the seas — hunted by industrial fishing fleets with a capacity to cover four Earth-like planets, over 80% of fish stocks are now fully exploited or nearing collapse. Over 90% of species, from sharks to tuna, swordfish to marlin, face extinction. With such overfishing — and the cruelty of 'bycatch', turtles, dugongs, manta rays, eels, destroyed within trawler nets — humanity could lose all seafood by 2048. With these ecosystems gone, 'dead zones' — hypoxia or low-oxygen sites, which cannot support life — will proliferate across the seas. Meanwhile, carbon emissions are stoking ocean acidification, threatening the loss of most coral reefs worldwide by 2050. The effects will be felt by a humanity that depends on these habitats, and their beings, to breathe.

Saving the oceans is an imperative now. As Times Evoke's global experts emphasise, intervention strategies abound. These include creating Marine Protected Areas (MPAs), limiting coastal building, redirecting toxic effluents and encouraging sustainable fishing. As the hope-filled example of Cabo Pulmo, Mexico, shows, ocean rejuvenation is still possible. Join Times Evoke on an exploration of such routes to revival, which can save the waters of wonders that fill us with life.

# 'The oceans give us oxygen — full of wondrous antiquity, the seas run through humanity's veins'

**Peter R Girguis** is professor of organismic and evolutionary biology at Harvard University. Speaking to **Srijana Mitra Das** at Times Evoke, the distinguished scientist and oceanographer explains why the sea is vital to humanity:

Your writing sometimes refers to the ocean as 'inner space' — can you explain this?

■ 'Inner space' is another way of thinking about the ocean. We frequently talk about exploring outer space. However, the exploration of outer space is actually easier than exploring the ocean. We can explore the cosmos using our eyes and optical instruments. You can look up on an evening and see the moon, which is hundreds of thousands of kilometres away. The ocean is just over 11 kilometres in depth and we still cannot see it. We are quick to think of exploring outer space — but there is this inner space that is far more challenging.

At another level, the inner space of the ocean, the conditions of its salt water, are no different than the conditions in our own bodies. We humans are like containers of salt water — the salinity of our blood, our cells, the chemicals found in us, are also found in the ocean. Scientists have discovered that the beginnings of life were in water. In this way, the ocean runs through our veins.

What are the connections between marine microbes and what term local and global biogeochemical cycles?

■ The ocean runs our planet — every breath we take has oxygen in it. Half of that oxygen comes from marine microbes. The other half comes from plants. Marine microbes therefore powerfully influence global biogeochemical cycles. This term represents how oxygen moves from the ocean to land, into the air, and then into people.

Importantly, marine microbes also provide protein for one-fourth of humanity. They take nitrogen from the air and turn it into amino acids and pro-



THE DEEPEST WONDERS: Housing phytoplankton, algae, reefs and microbes which produce oxygen and consume methane, every level of the ocean supports life

tein — they literally nurture us. Even the deepest of the deep sea provides nutrients. In the Indian Ocean, for example, surface waters are biodiversity hotspots. This is because of the cold, nutrient-rich water from the deep sea beyond the reaches of sunlight — that cold water comes to the surface and feeds algae. The algae feeds shrimp, which feeds fish. Thus, these extraordinary ecosystems exist, fed by the deep sea.

What are marine methane seeps and why are these important?

■ The ocean has microbes that consume the majority of methane on earth. Methane is an even more potent greenhouse gas than carbon dioxide. This is tied up in the deep sea as methane ice — it's a very strange material. It's like ice but it is actually methane trapped as a solid. Methane sometimes emerges from the sea floor as bubbles or seepage. These microbes then eat it.

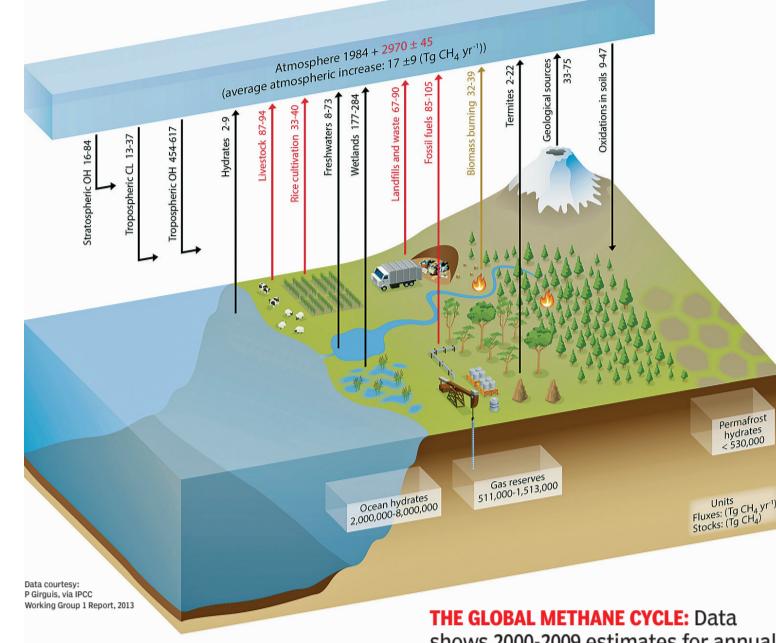
Certain sea animals have evolved a symbiotic relationship with such bacteria — these animals resemble clams or mussels, except they are about five to ten

times larger. These don't eat food like shallow mussels. Instead, they have evolved this relationship with bacteria that grow inside them. The mussels help deliver methane to the bacteria, which have a safe place to live in mussel tissue. The bacteria absorb the energy from this methane and feed themselves and the mussels. This astonishing relationship is hosted in methane seeps.

Worryingly, as more carbon dioxide now blankets the earth and temperatures rise, more and more of this methane is being released from the ocean, as well as the tundra, into the atmosphere. We have both methane producers and methane eaters. We don't know who is faster but the answer holds profound meaning for our well-being.

Is human activity damaging even microbial marine ecosystems?

■ Human activity is having a very serious effect on ocean life — it is changing the conditions of our atmosphere through carbon emissions. All these gases dissolve in sea water; changing the oceans. This is especially true in the up-



THE GLOBAL METHANE CYCLE: Data shows 2000-2009 estimates for annual methane fluxes (changes) in Tg (10<sup>12</sup> g) of Methane per year and methane reserves in Tg (CH<sub>4</sub>). The black arrows are natural fluxes, the red arrows are fluxes directly caused by human activities since 1750 and the brown arrows denote a combined natural and anthropogenic flux impacting methane — once ideally arranged by nature across land and sea

per ocean currently — animal life is struggling to cope with ocean acidity and temperature change. These problems will soon impact humanity — over 25% of us depend on the ocean. From fishing to tourism, if you sum up all the economic activities the ocean supports, it would itself be in the G7. So, when we change the ocean, we are hurting multiple natural ecosystems and humanity.

How can ordinary people help the seas?

■ The first thing to do is to read about the ocean. We're busy and often exhausted.

But you can nourish your soul by reading about the oceans and the amazing creatures in them. A life truth is that the ocean is a part of us and we are a part of it. We should all learn more about it.

Sometimes, people assume that you have to be an ocean scientist to help preserve the seas. That isn't so. One of my classes at Harvard is open to all. It includes lawyers, programmers, engineers, students, retirees. I teach deep sea biology here. At the beginning of

the course, people wonder, what can I do? At the end of it, they see they each have individual gifts they can offer. A computer designer can volunteer to help an ocean conservation group make an informative web page. An accountant can help a marine research group balance its budget. Everyone is skilled and our collective efforts can help others understand how without the ocean, this planet won't be habitable for us.

We must stop destroying this amazing and beautiful oceanic world — a place of antiquity which has been here from before humankind.

## OUR EXHAUSTED SEAS

Human activity is indelibly impacting the oceans — sewage and industrial effluents, oil spills and chemicals used in agriculture are polluting the seas, depleting oxygen and nutrients and killing marine plant and animal life

**Hawksbill turtle**  
Overfishing is driving the crisis — overfished wild fish stocks globally have tripled in the last 50 years. At current overfishing rates, the world will exhaust seafood by 2048. Almost 90% of the world's fisheries are now over-exploited, fully exploited, depleted or nearing collapse

**Climate change is harming the seas — air pollution is adding one-third of the toxic contaminants that enter oceans. Global warming is causing sea acidification — at current levels, most coral reefs could be lost by 2050**

**Hammerhead shark**  
60% marine ecosystems globally have been degraded — there are 500 'dead zones', covering over 2,45,000 km² in the seas, which are hypoxic or low-oxygen and cannot support life

**With limited habitats lost, ocean-dwelling species are vanishing twice as fast as land-dwelling species — extinction confronts overfished bluefin tuna and Acadian redfish, hunted hammerhead sharks and blue whales. Even the deep-sea scaly-foot snail is threatened by underwater mining, while the hawksbill turtle is often killed as 'bycatch'**

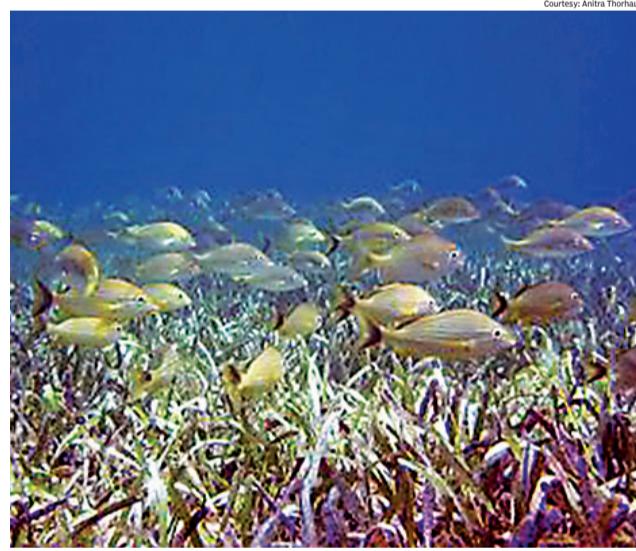
Only 1.6% oceans are protected, compared to 12% land worldwide. Yet, key revival strategies include creating Marine Protected Areas that prohibit fishing, banning sea hunting, minimising trawling, redesigning effluent systems away from seas and encouraging sustainable fisheries

Research: National Geographic, UNESCO, FAO, Encyclopaedia Britannica, IUCN

# 'The roots of stability: How seagrasses form the ocean's meadows of life'



**Graeme P Berlyn** is EH Harriman Professor of Forest Management and Physiology of Trees at Yale University. **Anitra Thorhaug** is a marine biologist, plant ecophysiological and chemical oceanographer, famous for her efforts to restore seagrass ecosystems. Writing in Times Evoke, the renowned scientists explain why 'the sea's meadows' are so crucial — and must be preserved:



THEIR HOME IN THE SEA: Fish shoals live within the seagrasses of the Biscayne Bay, Florida

absorbing pigments used in photosynthesis to maximise energy absorption and productivity.

Seagrasses have also lost the pores (or stomates) on their leaf surfaces that take up carbon dioxide in land plants. This is an adaptation to the aquatic environment and thus, seagrasses take in carbon through their leaf surface and release the oxygen formed in photosynthesis internally. They have developed the ability to pump oxygen down to their roots and rhizomes (underground stems) to support aerobic respiration — these roots and rhizomes intertwine in the sediments and help stabilise them, provide additional habitat for other organisms and give stability from storms and currents. They also produce genetically identical shoots and roots that form clonal colonies. Lateral growth by rhizomes or shoots is the normal growth pattern — thus, large segments of seagrass meadows may really be one single organism from this activity! These extensive organisms can live for hundreds of years.

Tropical areas in the Pacific and Indian oceans have multiple seagrass species in their bays and shorelines. The Atlantic tropics tend to have mead-

## HOW OCEANS BREATHE

- Seagrasses spread on the ocean floor capture 83 million metric tons of 'blue carbon' each year — seagrasses sequester 11% of organic carbon in the seas
- Seagrasses capture carbon upto 35 times faster than tropical rainforests. One acre of seagrass can sequester 335 kgs of carbon annually — the amount emitted by a car driving over 6,000 km
- Through photosynthesis, one sq metre of seagrass creates 10 litres of oxygen each day — one acre supports 40,000 fish and 50 million small invertebrates
- With 50% seagrass habitats destroyed by pollution, etc., once-abundant dugongs and sea turtles, which eat seagrass leaves, face existential threats

Research: Smithsonian Institution, Nature, BBC  
Stock

ows dominated by single species. The temperate and boreal zones have fewer species overall than the tropics. Seagrasses are found from Argentina, Chile, South Africa and Tasmania to the Arctic Circle, but these are particularly abundant in the tropics.

In recent years, seagrasses have been decimated by a series of human activities — anything that cuts light transmission of the water degrades seagrasses. This includes sewage as well as industrial and agricultural effluents. Dredging or filling is also decimating, as is shoreline development. Happily though, seagrass restoration is underway in North America, Europe, Japan, the Caribbean and Southeast Asia, where scientists are working to recover the estimated loss of 50% of our seagrass communities. The process involves finding sites where seagrasses existed previously and which are at least three feet in depth — with government permission, small portions of seagrasses as sprigs are transported to these sites and secured in sediments at three to four-foot intervals. This is done in low-energy times, such as before heavy storm periods. Within a month, scientists can measure how many of these sprigs have survived — and how many animals have come to inhabit these.

Approximately 1,71,000 square kilometres of seagrass meadows remain globally — however, researchers estimate that within 10 years, most will be lost, unless a major effort is made to restore them. Some nations are protecting seagrass meadows with designated marine protected areas (MPAs) and policies and regulations against destroying seagrass. Unfortunately, many other nations still have no policies or regulations for seagrasses yet. The fact is, seagrasses are undervalued — they cannot be easily seen as they grow below the water line and 'out of sight' does mean 'out of mind' for most people. However, this needs to change, for the good of the planet — and for the humans who live on it.

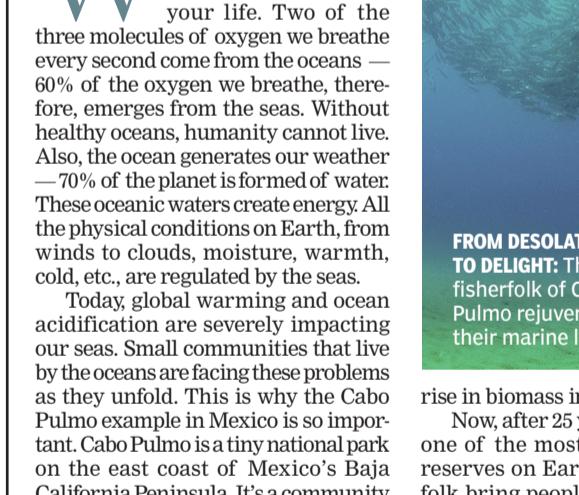
Whether you live on a coast or in a city far away, the sea is the foundation of your life. Two of the three molecules of oxygen we breathe every second come from the oceans — 60% of the oxygen we breathe, therefore, emerges from the sea. Without healthy oceans, humanity cannot live. Also, the ocean generates our weather — 70% of the planet is formed of water. These oceanic waters create energy. All the physical conditions on Earth, from winds to clouds, moisture, warmth, cold, etc., are regulated by the seas.

Today, global warming and ocean acidification are severely impacting our seas. Small communities that live by the oceans are facing these problems as they unfold. This is why the Cabo Pulmo example in Mexico is so important. Cabo Pulmo is a tiny national park on the east coast of Mexico's Baja California Peninsula. It's a community of around 300 people. It used to be a fishing village, but 25 years ago, the local people realised the area had been completely overfished — there was

completely nothing left in the sea. The state of empty waters, a dead zone in the ocean, was very hard to deal with.

But the fisherfolk of Cabo Pulmo did not give up — they decided to start protecting the reef. The first few years doing this were very difficult because they had almost nothing else to financially support them. But, after eight to ten years, with their dedication, the area's marine life recovered in an amazing way — from small fish to octopuses, mobula rays to corals, the marine community increased in abundance. The fish grew bigger in size, the total biomass increased and finally, after 15 years, the big predators, like sharks, which naturally control marine populations, returned. There has been a 400%

## FROM DESOLATION TO DELIGHT: The fisherfolk of Cabo Pulmo rejuvenated their marine life



FROM DESOLATION TO DELIGHT: The fisherfolk of Cabo Pulmo rejuvenated their marine life

rise in biomass in the ocean there.

Now, after 25 years, Cabo Pulmo is one of the most important marine reserves on Earth. The local fisherfolk bring people to experience eco-tourism there. They only fish outside the reserve and, interestingly, external areas have become enriched too, by the abundant numbers of fish that

migrate from the reserve to other places. The fisherfolk of Cabo Pulmo now earn higher incomes than any other coastal community in Mexico — if the Cabo Pulmo example was followed in other places, we could save the overfished ocean we have today.

The Revillagigedo Archipelago National Park is another important example. This archipelago has four volcanic islands belonging to Mexico, located 500 miles offshore. These islands have the most pristine marine life in Mexico. Before 2017, the islands only had a perimeter of protection around them. So, many industrial boats, especially tuna boats, would poach diverse species there. Then, scientists, conservationists, photographers and other concerned people joined together to ask the government to expand the protection of these islands. In 2017, the Mexican government made this the largest protected marine reserve in North America. It's now a national park spread over 1,48,000 square kilometres where absolutely no fishing is allowed. I am very hopeful that in five to eight years,

we will see a huge rebound of marine life in this area.

Some of my current work focuses on protecting coastal mangroves now. This ecosystem sequesters the most carbon from the atmosphere and contributes crucial ecological services to our planet — yet, in the last 50 years, we have lost almost 50% of the mangroves on Earth. A driving cause has been palm agriculture, with the need for oil from palms, used in packaged foods, detergents, cooking oils, etc., destroying mangroves. We are wrecking these amazing areas, thriving with life, standing between land and sea, for a packaged snack. What can be more thoughtless than that? It is vital we protect the mangroves left today. They save us from being eroded into the seas.

## TO PRESERVE AND GROW

Evidence shows trophic groups of reef fishes reviving after fishing was closed off in spots along the California Gulf

